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ABSTRACT

A study involving 18 hyperkinetic children (from 3- to 12-years old) was conducted to test the hypothesis that hyperactive children manifest the same type of hypermotility in their eyes as in the rest of their body. Ss were observed under a series of test conditions (including manual problem solving) which elicit short and long periods of fixation, pursuit movements, small and large saccadic movements (rapid, involuntary jumping of the eyes from one fixed point to another); and optokinetic nystagmus (rapid involuntary oscillation of the eyeballs); and eye movements were measured by electrooculography. In comparison to controls, hyperkinetic Ss were generally unable to hold their eyes steady either in direct forward or in lateral gaze; Ss tended to continue to use combined head and eye movements at a later age when problem-solving; and Ss tended to have more saccadic movements to non-target areas during pursuit. (Graphs are provided.) (SB)

Abstract SRCD, April 1975.

DO HYPERACTIVE CHILDREN HAVE MANIFESTATIONS OF HYPERACTIVITY IN THEIR EYE MOVEMENTS?

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Eye movements of normal and hyperkinetic children (ages 2.6-11) are being recorded by electrooculography to determine if the eye movements of the hyperkinetic children reflect their motoric overactivity. Children are studied under a series of test conditions, including manual problem solving, which elicit short and long periods of fixation, pursuit movements, small and large saccadic movements and optokinetic nystagmus. Previous findings of developmental changes in duration of fixations during reading and in maturation of scanning strategies in visual problem solving appear to be substantiated. In addition, normal children of 3-6 use more head and eye movements than younger or older children to orient themselves to different target areas when problem solving. Concomitant with the development of reading skills at age 7-8, head movements decrease during visual problem solving and eye movements are used alone to a greater degree. Normal children have no difficulty in maintaining gaze for prolonged periods without horizontal gaze shifts. Vertical movements and blinks are more common than horizontal movements when attempting to hold the eyes steady. To date hyperkinetic children have shown several differences from their age matched controls. 1) They are generally unable to hold their eyes steady either in direct forward or in lateral gaze. 2) They appear to have more saccadic interruptions of pursuit movements than normal children. 3) They tend to continue to use head movements at a later age when problem solving. 4) They have more saccadic movements in darkness than normal children. The impersistence of gaze and the apparent increase in saccadic movements during pursuit, if substantiated in a larger group, could be important for use in differential diagnosis of hyperkinesis. The continued use of head and eye movements during problem solving in hyperkinetics is of interest because it suggests a difference in rate of development. Taken together these qualitative and quantitative findings could contribute to the perceptual and learning difficulties found in hyperkinetic children.

DO HYPERACTIVE CHILDREN HAVE

MANIFESTATIONS OF HYPERACTIVITY IN THEIR EYE MOVEMENTS?

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The hyperkinetic syndrome is a disorder of childhood characterized by involuntary overactivity. The children appear to be constantly in motion but their actions are frequently without clear objectives. They may have deficits of coordination, associated movements, and fine motor activity. Speech and hearing may also be affected. Although they may be of normal or superior intelligence, they frequently do poorly in school. In part this may be ascribed to attentional, perceptual and visual-motor coordination deficits. Later they show impulsive behavior and frequently enter adolescence with residual learning deficiencies and personality problems that may lead to continuing educational and social problems as they grow older.

The causes and physiology of hyperkinesis are not well understood and diagnosis is often difficult. It seems clear that excessive or unfocussed motor activity is an important sign in hyperkinetic children. However, most previous studies of hyperkinetic children have been largely quantitative or descriptive in nature. Consequently, there is little quantitative information as to how these children differ from normals. Millichap and Boldrey (1967) utilized a self-winding wrist watch in an attempt to quantify body hyperactivity in brain-damaged children. The watch recorded the movements of the hand and wrist as the child played in a standard environment. However, this device did not record motion of the legs or swinging or rocking movements of the trunk which are frequently observed in brain-damaged and mentally retarded children. Other devices have been used to make direct measurement of physical movement including mechanical pedometers, ballistocardiographs, a room fitted with photo-electric cells and sources of light, and telemetry. The details of these quantitative techniques are summarized by Werry and

Sprague (1971). The galvanic skin response has also been used in an attempt to provide quantitative data. Satterfield and Dawson (1971) found that hyperkinetic children had lower galvanic skin resistance than normals. The electrodermal abnormality was corrected by amphetamine therapy.

The present study was undertaken to test the hypothesis that hyperactive children manifest the same type of hypermotility in their eyes as in the rest of the body. If ocular hypermotility were present in hyperactive children, it could be used to diagnose the condition, as well as being an index of effectiveness of therapy. In addition, there is general agreement that many hyperkinetic children exhibit perceptual problems, and that problems involving central cognitive processing may be mirrored in eye movements. One might, therefore, expect to find differences between the eye movements of hyperkinetic and normal children. Understanding of such differences could lead to better planning and evaluation of remedial programs. In this paper We will describe our test methods, and give some preliminary results. We plan a more complete presentation of results in the future when data analysis is completed.

Subjects

Thirty-four normal and eighteen hyperkinetic children, predominantly males aged 3 - 12, have been tested so far. Normal children were recruited from private schools in New York City. Hyperkinetic children were drawn mainly from the Pediatric Neurology Clinic at Elmhurst Hospital which serves a middle-class and lower-middle-class population.

Hyperkinesis was diagnosed on the basis of history, neurological exam-

ination, psychiatric evaluation and psychological testing. Because hyperkinesis is a symptom and not a disease, there are a number of conditions with which it is associated. For this reason the children have been separated into several groups. One includes those with definite signs of brain dysfunction or organicity such as retardation, seizure disorders, or a past history of meningitis or encephalitis. A second group consists of children without specific or "hard" neurological signs. Nine of the hyperkinetics we have tested fall into the second group. Four were ~~examined on two~~ occasions.

Methods

During testing children sit in a chair with an adjustable head and chin support. Head restraint if necessary is provided by an examiner holding the head lightly. Eye movements are recorded by electrooculography (EOG). Electrodes are placed alongside and above and below the eyes. EOG voltages are recorded by a paper writer and stored on FM magnetic tape for later analysis.

An important question was whether stable eye movement recordings could be taken from both pre-schoolers and hyperkinetics. In particular, would the children sit still long enough, i.e. 30-45 minutes, to permit testing? After considerable experience, the answer is yes. If electrodes are correctly applied, EOG records are stable, drift is minimal and it is possible to determine eye position accurately. As with all eye movement recording techniques, EOG is not without technical difficulties. It is subject to drift and is not suitable for analysis of movements smaller than 1° to 2°. It is not a reliable indicator of eye position during blinks and facial tics. However, it gives a continuous measure of eye position, and can be used without immobilizing the head.

Eye movements including horizontal and vertical saccades and pursuit

movements in both planes are induced by visual stimuli projected on a white translucent screen 1 meter from the subject. First, a film is presented in which white dots appear on a dark background to induce horizontal and vertical saccades of known amplitude and pursuit movements. Pursuit movements are evoked by a white dot moving back and forth at 22.5° per second in the horizontal and vertical planes. Most of the data presented here is related to the horizontal pursuit task. Scanning and pursuit movements are also induced by an ambiguous heart-shaped figure similar to that used in the Russian studies, by the Raven's Matrices, and by reading slides. All children watch an optokinetic drum moving at different velocities. With the head free, they then perform two trials of the Seguin Form Board.

For analysis the EOG is fed into a digital computer which digitizes measured segments of horizontal and vertical components of movement. Programs identify the beginning and ends of eye movements and blinks. A replay of digitized data from the computer is presented in Figure 1.

The downward deflection of the traces in A & B shows two movements to the left which occurred during horizontal pursuit. The beginning of each movement is marked by a small upward pulse and the end by a small downward pulse. This shows that the program accurately identifies and marks both small and large saccades. C shows horizontal and vertical EOG recordings during two horizontal movements to the left of about 2°. There was no deflection in the vertical EOG, (the lower trace) indicating that the eyes did not move up or down during the movements. Notice that although the movements were of different durations, the beginnings and ends were correctly marked.

Figure 1

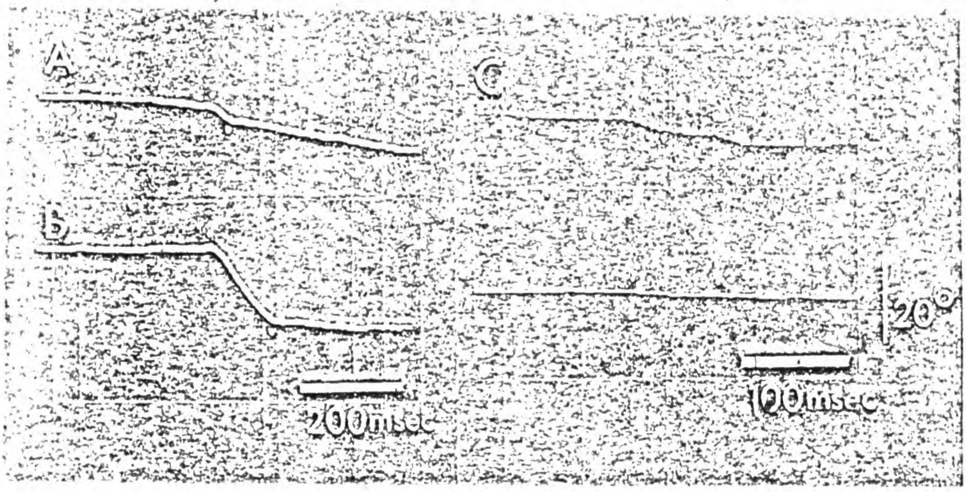


Figure 2

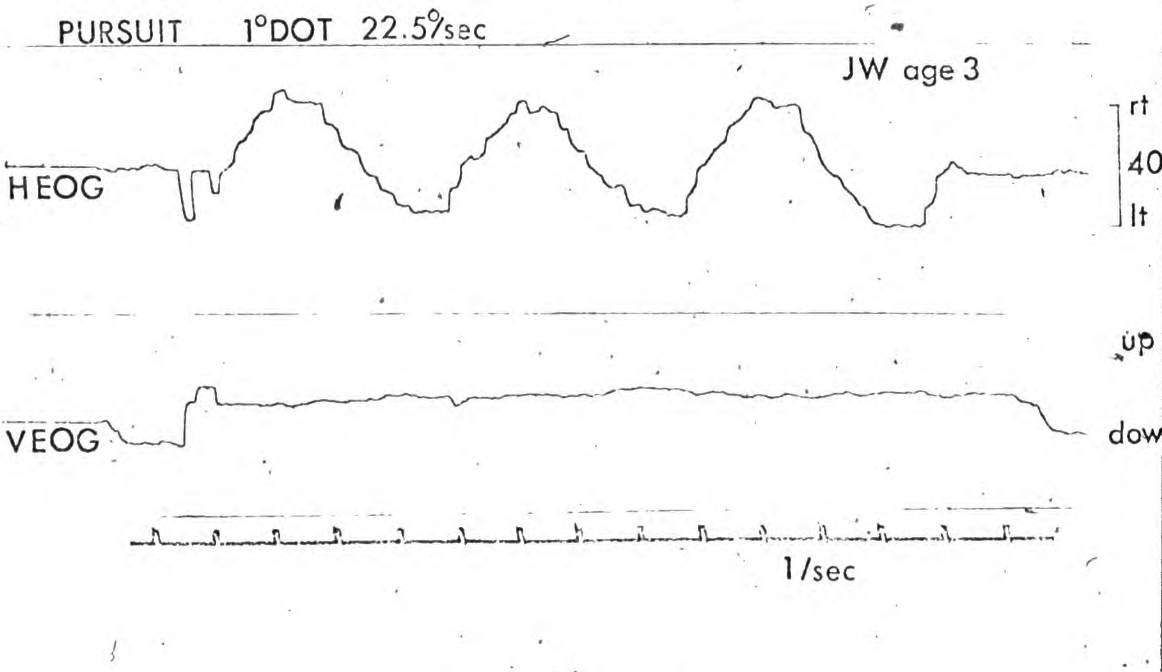


Figure 2 shows a sample of horizontal pursuit of a normal three year old responding to a white dot moving horizontally at 22.5°/sec across 40° of the visual field. The time base shown below is 1 mark/sec, and is the same for all remaining figures. As the child pursued the dot, there were some horizontal but no vertical saccades. This figure shows that even young children can perform the task well. Note, that there was no cross-coupling between the horizontal and vertical EOG. That is, horizontal eye movements did not cause trace deflections in the vertical EOG.

Figure 3 shows horizontal pursuit of normal and hyperkinetic boys of different ages. On the left are records of the normal children and on the right, the hyperkinetic children. Normal children either pursued the target smoothly or had small saccadic movements as the dot moved back and forth. Once they moved "on target" they followed the dot for the rest of the trial, approximately 15 seconds. In contrast, the pursuit of the hyperkinetics was more irregular, and there were more saccades interrupting pursuit in almost every instance. The lines over the record in K show the path which the eyes should have taken if they were moving at the speed of the dot, 22.5°/sec. In this child as in other hyperkinetics, there were generally several large saccades away from the path of the moving dot in the later portions of the record.

Another difference we found was the apparent inability of some hyperkinetic children to hold their eyes steady. Figure 4 shows records of two six-year old males attempting to stare. The normal child was able to maintain gaze steadily for 45 seconds with only a few blinks in the vertical trace while the hyperkinetic boy was unable to maintain gaze for even a few seconds over three trials.

There also appear to be developmental differences in the way normal and

Figure 3

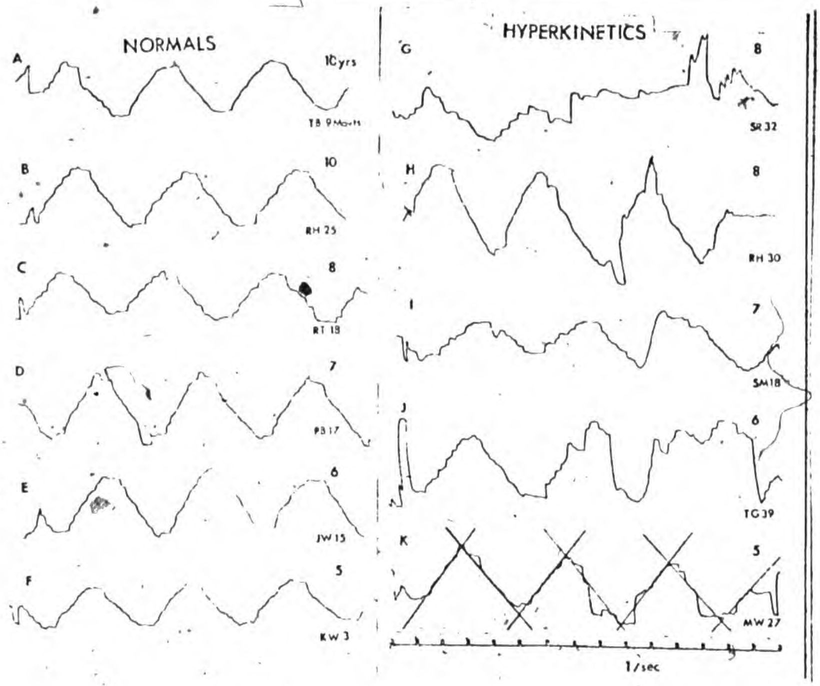
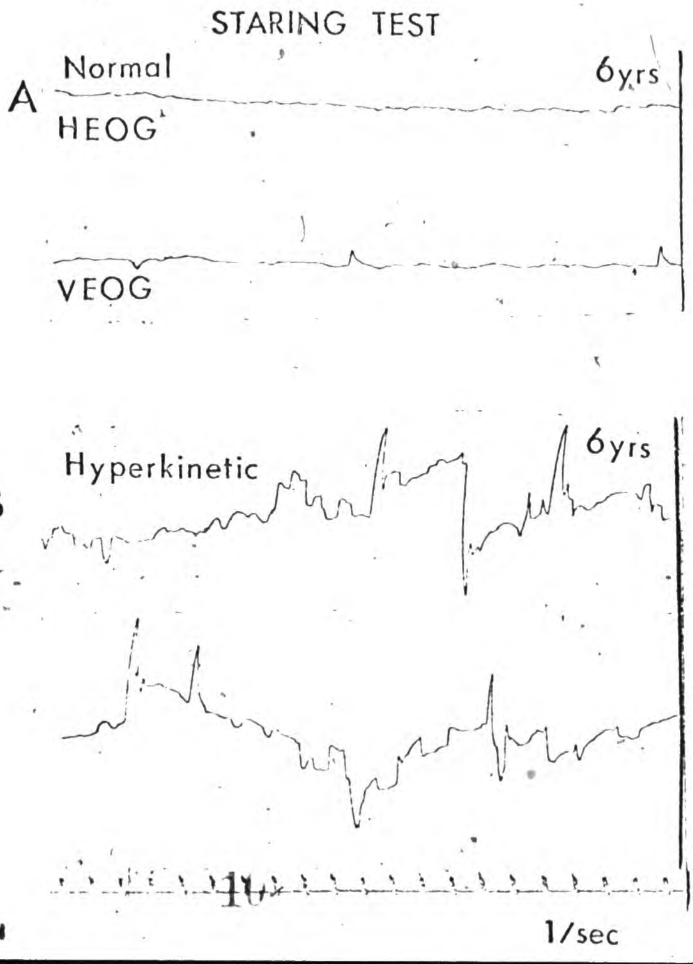


Figure 4

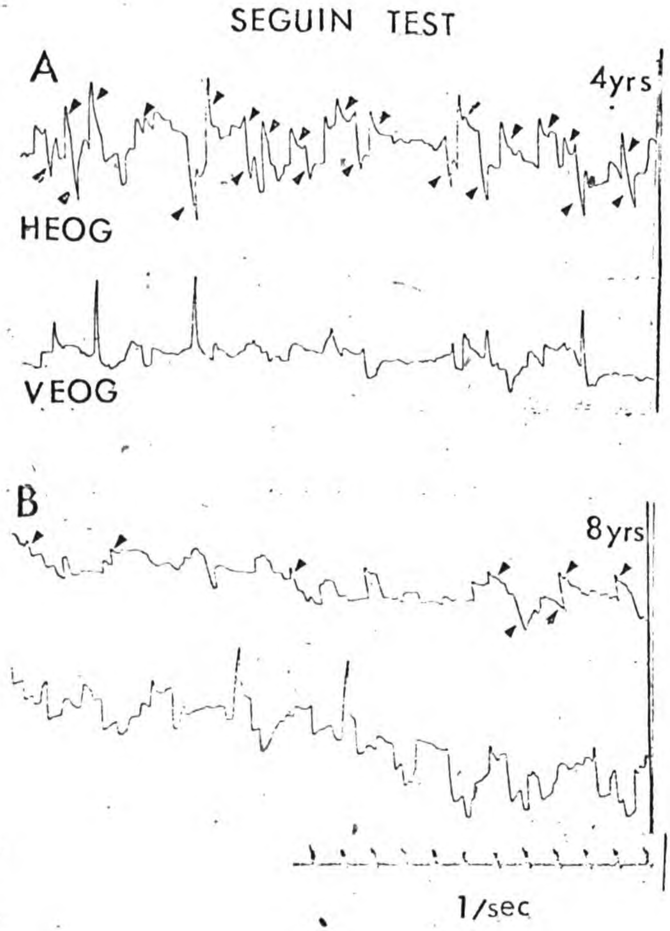


hyperkinetic children coordinate their head and eye movements during the Seguin task when the head is free. Figure 5 shows records of two normal males, ages 4 and 8. Arrows mark eye movements associated with head movements. Head movements can be detected by the special characteristics of the accompanying eye movements. A saccadic eye movement is followed immediately by a slow compensatory eye movement in the opposite direction as the head moves towards the target. Estimates of head movement from the EOG were checked independently having another observer count the head movements during the Seguin test. Agreement was usually within 10%. As shown in Figure 5, the older child used fewer head movements than the younger one. Similar age-related differences were found in other normal children. Also, the older children had more vertical than horizontal head movements. Much of the hyperkinetic data is still to be analyzed, but it appears that 7 - 10 year old hyperkinetics used more head movements than their age-matched controls. In this respect, they behaved like younger control subjects.

Several children who were classified as hyperactive because of late appearing restlessness and who apparently became hyperactive in response to emotional stress have not had different eye movement records from those of normal children. Conversely, two children who demonstrated hyperactivity at a young age have had more eye movements than their age-matched controls.

Thus far, hyperkinetic children have shown several differences from their age matched controls. (1) They have generally been unable to hold their eyes steady either in direct forward or in lateral gaze. (2) They tend to continue to use combined head and eye movements at a later age when problem-solving. (3) They tend to have more saccadic movements to non-target areas during pursuit than normal children.

Figure 5



The impersistence of gaze and the apparent increase in inappropriate saccadic movements during pursuit, if substantiated in a larger group, could be important for use in differential diagnosis of hyperkinesis. We would emphasize that these findings are preliminary and that a number of controls must be run including matching for I.Q. and for socio-economic status to ensure that the differences we have found are not related to variables other than hyperkinesis. However, taken together these qualitative and quantitative findings indicate that eye movement recordings may contribute new information for understanding the pathophysiology as well as the learning difficulties related to the attentional and possibly perceptual problems found in hyperkinetic children.

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